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EMISSIONS FROM DOD FUEL STORAGE AND PAINTING OPERATIONS

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13. ABSTRACT ***(Maximum 200 Words)***
The USEPA's National Risk Management Research Laboratory (NRMRL), under the direction and support of the Strategic Environmental Research and Development Program (SERDP), was funded to develop a process for controlling volatile organic compounds (VOCs) from fuel storage and transfer operations. The Naval Facilities Engineering Service Center (NFESC) was tasked to quantify DoD emissions form these operations. It was determined that Navy fueling operations are in compliance with Clean Air Act requirements and that by switching to JP-8 as a primary aircraft fuel, the Air Force and Army fueling operations will also be compliant. DoD painting operations were examined as another VOC source appropriate for control with the NRMRL developed process. Compliance with regulatory requirements may involve using low solvent content coatings, installation of "end of the stack" air pollution control equipment, emissions averaging, or changes in paint application techniques. One disadvantage of the DoD trend to switch to low VOC coatings is the difficulty of application and their performance in harsh environs.

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency's National Risk Management Research Laboratory (NRMRL), under the direction and support of the Strategic Environmental Research and Development Program, was funded to develop a process for controlling volatile organic compounds (VOCs) from fuel storage and transfer operations. The Naval Facilities Engineering Service Center (NFESC) as a partner of NRMRL, was tasked to quantify Department of Defense (DoD) emissions from these operations. It was determined that Navy fueling operations are in compliance with Clean Air Act (CAA) requirements and that by switching to JP-8 as a primary aircraft fuel, the Air Force and Army fueling operations will also be compliant.

NFESC was then directed to identify other VOC sources appropriate for control with the NRMRL developed process. DoD painting operations were examined for this purpose. Painting operations in the DoD are primarily affected by the "Aerospace Manufacturing and Rework Facilities" and the "Shipbuilding and Ship Repair (Surface Coating)" National Emission Standards for Hazardous Air Pollutants (NESHAP). These NESHAPs regulate emissions of VOCs that are designated to be Hazardous Air Pollutants (HAP) by Section 112(b) of the CAA. Total VOC emissions from painting operations are also subject to the requirements of the pertinent CAA state implementation plan (SIP).

Compliance with these regulatory requirements may involve using low solvent content coatings, installation of "end of the stack" air pollution control equipment, emissions averaging (e.g., application of high HAP topcoats with low HAP topcoats), or changes in paint application techniques. Although there has been a trend within DoD to switch to low VOC coatings to achieve compliance. there is one distinct disadvantage of this choice. The formulation of low VOC coatings tends to make them more difficult to apply, and in the case of water born paints, seriously hinders their performance in harsh environments. This is a major concern when specialty paints are required, as is the case for chemical agent resistant coatings (CARC) that are frequently used by the Army and Marine Corp.

The need to use an air pollution control device can be paramount in those situations where low VOC coatings are not appropriate and also in instances when a SIP mandates VOC emission reductions. These two areas will no doubt increase in importance as CAA requirements become more stringent and DoD installations are faced with the imposed limitations in their day to day operations.

EMISSIONS FROM FUEL STORAGE AND TRANSFER OPERATIONS

Navy fuel storage and handling operations are subject to regulation under the National Emission Standards for Hazardous Air Pollutants (NESHAP) source category titled "Marine Tank Vessel Loading (MTVL) Operations." This NESHAP specifies that an MTVL operation is subject to Maximum Achievable Control Technology (MACT) if: 1) the operation is a major hazardous air pollutant (HAP) source or if the operation is located on a facility that is a major HAP source, and 2) if the MTVL operation handles fuels with vapor pressures greater than 1.5 psia. A major source is defined by the Clean Air Act (CAA) as emissions exceeding 10 tons/year of single HAP or an aggregate total of 25 tons/year of all HAPs. A MACT standard may entail an add-on air pollution control device, but may also entail changes to a sources design, equipment, processes, materials, or operations.

The two Navy fuels affected by the MTVL rule are JP-5 and Navy Distillate fuel (F76, or diesel #2). Table 1 contains annual fuel throughput capacity for the Navy's largest fuel terminals. Throughput is the total of actual fuel transfer and is comprised of total fuel received, issued, and transferred for custodial purposes. The data was obtained from the Navy Petroleum Office, Cameron Station, VA (Swaidan, 1995).

Table 1 - Annual Fuel Throughput at Navy Fuel Terminals

Navy Terminal	Navy Distillate Fuel	JP-5
Norfolk, VA	356,126,370	138,386,055
San Diego, CA	279,231,082	79,078,805
Pearl Harbor, HI	129,807,030	20,323,797
Jacksonville, FL	65,769,580	69,713,895
Charleston, SC	45,420,850	891,990
Puget Sound, WA	36,155,900	25,071,000
Oakland, CA	20,257,627	9,958,245
Pennsacola, FL	1,932,770	33,130,540

The NESHAP compliance status is summarized in Table 2 for the Navy's largest fuel terminal, which is located in Norfolk, VA. Total annual HAPs emissions from Navy Distillate fuel and JP-5 occur at rates of 0.0016 pounds of HAPs per kilogallon (lb/kgal) of fuel throughput and 0.00027 lb/kgal respectively (Radian Corporation). Total VOC emissions from Navy Distillate fuel and JP-5 occur at rates of 0.0046 lb/kgal and 0.0054 lb/kgal, respectively (Fu, 1994).

Table 2 - Emissions From Norfolk Fuel Terminal

	Throughput (gallons)	HAP Emissions (pounds/yr)	VOC Emissions (pounds/yr)
JP-5	138,386,055	37	32,224
Navy Distillate Fuel	356,126,370	570	15,008
TOTAL	496,987,471	607	47,232

Table 3 contains summaries of fuel storage and handling operations for the largest Army and Air Force fuel terminals. Fuel emission inventories indicate that these fuel terminals have HAP emissions far below the CAA major source threshold. In addition, with the exception of gasoline, all Army and Air Force

Table 3 - Emissions From Air Force and Army Fuel Terminals

	Throughput (gallons)	HAP Emissions (pounds/yr)	VOC Emissions (pounds/yr)
Air Force			
JP-4	--	--	--
JP-5	--	--	--
[1]JP-8	89,981,285	100	20,952
[2]Diesel	2,898,900	13	122
Gasoline	--	--	--
TOTAL	92,880,185	113	21,074
[3]Army			
JP-4	402,762	177	3540
JP-5	--	--	--
JP-8	--	--	--
Diesel	572,284	23	3
Gasoline	1,500,000	1400	28,000
TOTAL	2,475,046	1600	31,543

[1] Data on JP-8 is from Travis AFB, which throughputs the largest amount of JP-8 in the Air Force.
[2] Data on diesel is from Lackland AFB, which throughputs the largest amount of diesel in the Air Force.
[3] Army data is from Fort Richardson, which throughputs the most fuels in the Army.

fuels have vapor pressures below the CAA cutoff of 1.5 psia. Gasoline is exempt from regulation if monthly throughput quantities are less than 10,000 gallons per month. The Army is the only service handling gasoline in quantities exceeding the 10,000 gallon throughput threshold. The tanks utilized by the Army are equipped with vapor control devices that are compliant with the "Gasoline Distribution Facilities" NESHAP.

Since it has been determined that DoD fuel storage and handling operations are compliant with CAA requirements, NFESC was directed to identify other VOC sources that may be subject to "end of the stack" air pollution control requirements.

DoD VOC EMISSIONS DATA

As a first step in the data collection process, the Naval Facilities Engineering Service Center (NFESC) obtained records on DoD installations that are required to apply for Title V Clean Air Permits. Out of the 85 Army installations that were surveyed, 23 will require Title V permits based on HAP emissions, and an additional 15 may also require permits pending further emissions evaluations. Out of the Navy/Marine Corps 125 total installations, 86 will require Title V permits based on HAP emissions. Complete records for the Air Force were unavailable, although it is estimated that over 50% of all Air Force bases (173 total) will require permits. Other DoD installations may require Title V permits if they are located in non-attainment areas for ozone and are classified as a major source, based on the air pollution severity of the region.

Beyond Title V permitting data, Toxic Release Inventory (TRI) data was used to determine the largest emissions of VOCs within the DoD. TRI data provides information to the public about releases of toxic chemicals into the environment. Facilities that manufacture or process a listed TRI chemical in excess of 25,000 pounds in a calendar year or otherwise use a listed chemical in excess of 10,000 pounds within a calendar year are required to submit TRI reports to the EPA and the local state environmental regulatory agency. Of the approximately 383 DoD installations in the United States, 131 are required to file TRI reports. TRI data for the top ten chemical releases from DoD activities are listed in Table 4.

In 1994, air emissions represented over 97% of all toxic chemicals released by DoD. DoD's releases are primarily to air because maintenance activities such as painting and depainting of aircraft, cleaning, and degreasing, all use large amounts of highly volatile compounds. Table 4 indicates that the majority of chemical releases for DoD in 1994 were organic compounds, with the exception of zinc compounds and phosphoric acid.

Table 4 - TRI Top Ten Chemicals Reported For DoD

Chemical	Pounds
Dichloromethane	2,404,203
Methyl ethyl ketone	1,499,250
1,1,1-Trichloroethane	1,231,470
Phosphoric acid	636,577
Ethylene glycol	588,067
Toluene	448,266
Phenol	411,988
Zinc Compounds	409,180
Tetrachloroethylene	359,039
Hexachloroethane	351,370

The largest DoD sources of TRI emissions are listed in Table 5. These activities account for 90 percent of the total DoD TRI emissions.

Table 5 - TRI-Top DoD Installations

Installation	Total Pounds
Air Force	
Tinker Air Force Base, OK	1,569,614
Robins Air Force Base, GA	776,616
Hill Air Force Base, UT	367,909
Kelly Air Force Base, TX	344,631
McClellan Air Force Base, CA	340,750
Edwards Air Force Base, CA	170,976
Arnold Air Force Base, TN	154,096
Army	
Anniston Army Depot, AL	1,372,853
Pine Bluff Arsenal, AR	721,364
Red River Army Depot, TX	180,224
Letterkenny Army Depot, PA	144,485
Watervliet Arsenal, NY	104,275
Holston Army Ammunition Plant, TN	101,917
Lake City Army Ammunition Plant, MO	83,911
Rock Island Arsenal, IL	67,000
Fort Hood, TX	57,550
Marines	
Marine Corps Logistics Base Barstow, CA	322,011
Marine Corps Air Station Cherry Point, NC	315,370
Marine Corps Logistics Base Albany, GA	282,273
Marine Corps Blount Island Command, FL	20,000
Marine Corps Air Station Yuma, AZ	1,050
Marine Corps Base Quantico, VA	34
Marine Corps Recruit Depot Parris Island, SC	5
Navy	
Naval Air Station Jacksonville, FL	325,648
Naval Air Station Alameda, CA	227,500
Norfolk Naval Shipyard, VA	186,090
Norfolk Naval Base, VA	133,830
Philadelphia Naval Shipyard, PA	129,340
Puget Sound Naval Shipyard, WA	94,900
Naval Air Warfare Center, Patuxent River, MD	76,174

The installations in Table 5 were targeted in the collection of detailed emissions data. Complete emission inventories were available for two Army, two Navy, and one Air Force base on the TRI top ten lists. Emission inventory for these sites is presented in Table 6. Total emission figures are given in tons per year (TPY).

Table 6 - Emissions Inventory for a Sampling of Large Installations

Installation	Source	Total VOC (TPY)	HAPS Only (TPY)
Norfolk Naval Base	Painting/Coating	38.2	24.8
Norfolk, VA	Paint Booth	13.1	9.1
	Cleaning/Degreasing	1.5	1.5
	All Other Sources	397.5	94.2
	Non-VOC HAPS	--	80.8
	TOTAL	450,3	210.4
Puget Sound	Painting/Coating	0.1	0.1
Naval Shipyard	Paint Booth	46.2	14.1
Bremerton, WA	Cleaning/Degreasing	10.3	5.3
	All Other Sources	9.7	9.7
	Non-VOC HAPS	--	0.4
	TOTAL	66.3	29.6
Corpus Christie	Painting/Coating	249.7	249.7
Army Depot	Paint Booth	64.1	64.1
Corpus Christie, TX	Cleaning/Degreasing	178.4	178.4
	JP-4 Storage/Handling	1.4	1.4
	All Other Sources	128.6	128.6
	Non-VOC HAPS	--	0.00
	TOTAL	622.2	622.2
Red River	Painting/Coating	11.5	11.1
Army Depot	Paint Booth	52.1	46.3
Texarkana, TX	Cleaning/Degreasing	0.00	0.00
	Gasoline	5.9	5.9
	All Other Sources	51.1	51.1
	Non-VOC HAPS	--	6.3
	TOTAL	120.6	120.7
Kelley	Painting/Coating	--	--
Air Force Base	Paint Booth	21.5	21.5
San Antonio, TX	Cleaning/Degreasing	156.4	156.4
	Gasoline	10.1	10.1
	JP-4 Storage/Handling	7.0	7.0
	JP-8 Storage/Handling	18.6	18.6
	All Other Sources	175.5	164.7
	Non-VOC HAPS	--	18.9
	TOTAL	389.1	397.2

Data for Corpus Christie and Red River Army Depots, and Kelley Air Force Base was gathered from emission inventory reports provided by the Texas Natural Resource Conservation Commission. Information for the Navy activities was compiled from published sources (Kinsbury, 1992). Source areas were divided into painting/coating, paint booth, cleaning/degreasing, fuel handling/storage (if available), and other. Other sources include boilers, engine tests, and miscellaneous maintenance operations. A distinction was made between painting/coating, which is assumed to take place in open shop areas, and paint booths. This distinction was made in the original inventory reports. It is important to note that some of the painting/coating emissions may actually have come from paint booths, but were not listed as such. Thus, the paint booth emissions in Table 6 may be lower than actual.

Other significant sources of VOC emissions at DoD activities are cleaning and degreasing operations, paint stripping, and painting. Although there are a variety of VOC sources within DoD, only those sources whose emissions can be readily contained are appropriate for a vapor control system. Cleaning and degreasing operations within DoD have been largely converted from solvent based methods to aqueous cleaning. This change will result in a large reduction in VOC emissions from these operations.

DoD PAINTING OPERATIONS

Paint booths are large contributors of VOC emissions in the DoD and, as exhaust gases are readily controlled, are potential candidates for VOC control through "end of the stack" methods. A more detailed investigation was needed to determine the typical operating parameters of DoD paint booths and characterize their emissions. To simplify this investigation, the paint booths were categorized according to ventilation air flow rates as shown on Table 7.

Table 7 - Paint Booth Specifications

Booth	Typical Flow (CFM)	Typical Dimensions (ft)	Paint (Gals/week)
Small	3,200		
Medium	10,000	9 x 9 x 10	10
Large	17,000	15 x 10 x 20	20

A survey was then conducted to determine the number of operating paint booths of each category within the DoD. Results of this survey are summarized in Table 8. The number of paint booths on Marine Corps bases is an average between Army and Navy installations.

Table 8 - DoD Paint Booth Inventory

Paint Booth Size	[1] Air Force	[2] Army	[3] Navy
Small	14(0)	43(0)	30(1)
Medium	20(0)	39 (1)	47(1)
Large	9(0)	27(0)	31(0)
TOTAL = 260(3)	43(0)	109(1)	108(2)

NOTE: Numbers in parentheses indicate the number of sources currently equipped with air pollution control devices.

[1] 5 Air Force installations were surveyed
[2] 88 Army installations were surveyed
[3] 24 Navy installations were surveyed

The results of the paint booth survey were used to determine an average number of paint booths per DoD activity. The calculated averages are presented for each service in Table 9.

Table 9 - Average Number of Paint Booths at DoD Installations

Booth	Air Force	Army	Navy	Marine Corps
Small	2.8	0.5	1.25	0.75
Medium	4.0	0.45	2.0	1.0
Large	1.8	0.3	1.3	0.75

Table 10 tabulates VOCs detected in paint booth exhausts by Acurex Corporation at Hill Air Force Base, UT [Ayer, 1990a] and at Travis Air Force Base, CA [Hughes, 1994]. Concentration measurements were acquired in the exhaust ducts by drawing gas samples through charcoal tubes. Organic constituents adsorbed onto the charcoal were extracted with a solvent and analyzed with a gas chromatograph/flame ionization detector. Continuous sampling was performed in the exhaust duct to determine emission rates.

Table 10 - VOC Concentrations in Paint Booth Exhaust

Compound	Maximum (mg/m^3)	Median (mg/m^3)
Ethyl Acetate	45.5	7.6
2-Ethoxyethyl Acetate	37.7	6.9
* Methyl Ethyl Ketone	67.5	5.8
Methyloxyacetone	22.5	0.9
* Methylisobutyl Ketone	15.0	0.8
Butly Acetate	13.8	8.0
* Tolulene	26.4	8.6
* Xylenes	6.9	0.4
Ethoxyethanol	4.0	0.7
* Ethylbenzene	1.6	0.7
2-Butoxyethanol	1.0	0.1
Total VOC	185.0	41.0

* Hazardous air pollutants

An estimate of the total VOC emissions by DoD paint booths can now be acquired by multiplying the VOC concentration in the booth exhaust by the total ventilation through all paint booths. The results are tabulated on Table 11. Assuming small booths are used 30 hrs/week, medium booths operated 10 hrs/week, and large paint booths are used an average 2 hours/week, the total VOC emissions by all DoD paint booths is equal to about 4000 tons per year.

Table 11 - Total VOC Emissions from DoD Paint Booths

Branch	Booth Size	Number of Booths	Total VOC Emissions, tons/year
Air Force (173 Installations)	Small	484	805
	Medium	692	1,199
	Large	311	733
Army (85 Installations)	Small	43	72
	Medium	38	66
	Large	26	61
Navy (107 Installations)	Small	134	223
	Medium	214	371
	Large	139	328
Marine Corps (18 Installations)	Small	14	23
	Medium	18	31
	Large	14	33
Total Emission (383 Installations)			3,945

CONCLUSIONS

VOC emissions from paint booths that are considered major sources must be controlled. A paint booth is considered a major source if: 1) it is located on an installation that is a major source of HAPs, 2) if it is, itself, a major source of HAPs, or 3) if it is located on an installation that is considered a major source of VOCs in an ozone non-attainment area. Major HAP sources are required to comply with the MACT based NESHAPS. Major VOC sources in ozone non-attainment areas must comply with the controls set forth in the state implementation plan (SIP), which varies depending on the air pollution severity of the region and the individual requirements of the state.

Painting operations in the DoD are primarily affected by the "Aerospace Manufacturing and Rework Facilities" and the "Shipbuilding and Ship Repair (Surface Coating)" NESHAPS. These NESHAPS limit the emissions of HAPS (and VOCs) during a variety of coating operations, including primer and topcoat application. These emissions reductions can be achieved by using low solvent coatings, control equipment, or emissions averaging (i.e., application of high HAP topcoats with low HAP topcoats). Although most installations have switched to low VOC coatings to comply with this NESHAP, there is one distinct disadvantage of this choice. The formulation of low VOC coatings tends to make them more difficult to apply, and in the case of water born paints, seriously hinders their performance in harsh environments. This is a major concern when specialty paints are required, as is the case for chemical agent resistant coatings (CARC) which are frequently used by the Army.

Painting operations in the DoD are also subject to individual requirements under a state's implementation plan. These requirements are at least as strict as those requirements in the NESHAP, but may be more strict. In addition, SIPS require offsets in existing source emissions for each new or modified source. This emission offset can be as high as 1.3 to 1, depending on the air pollution severity of the ozone non-attainment region. This means that for every new ton of emissions, a reduction of 1.3 tons of existing emissions must be achieved.

The use of an alternate control can be paramount in those situations where low VOC coatings are not appropriate and also in instances when emissions offsets are required. These two areas will no doubt increase in importance as CAA requirements become more stringent and DoD installations are faced with the imposed limitations in their day to day operations.

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